Sintering and Desulphurizing of Iron Ore Materials

AMERICAN ORE RECLAMATION COMPANY

American Ore Reclamation Company

Sample of Sintered Material Showing Cellular Character of Product.

"A chemical action can only take place between two bodies, however great their affinity, it they are in intimate contact with each other; and the rapidity of this action will be so much greater, the more numerous the points of contact are."

Main Office: 71 Broadway, New York City

Chicago Office:

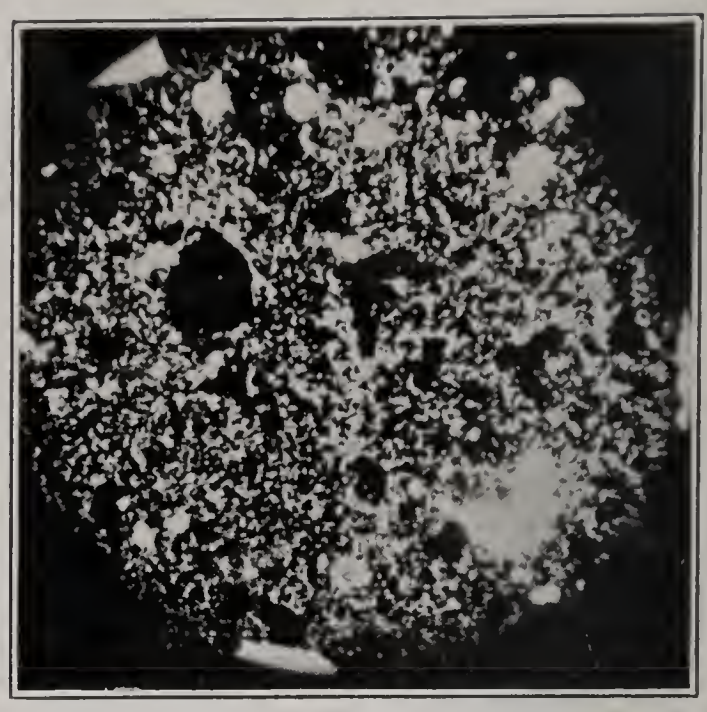
American Sintering Company · Railway Exchange Building

Microphotographs

PUDDLE CINDER

Magnified 40 Diameters

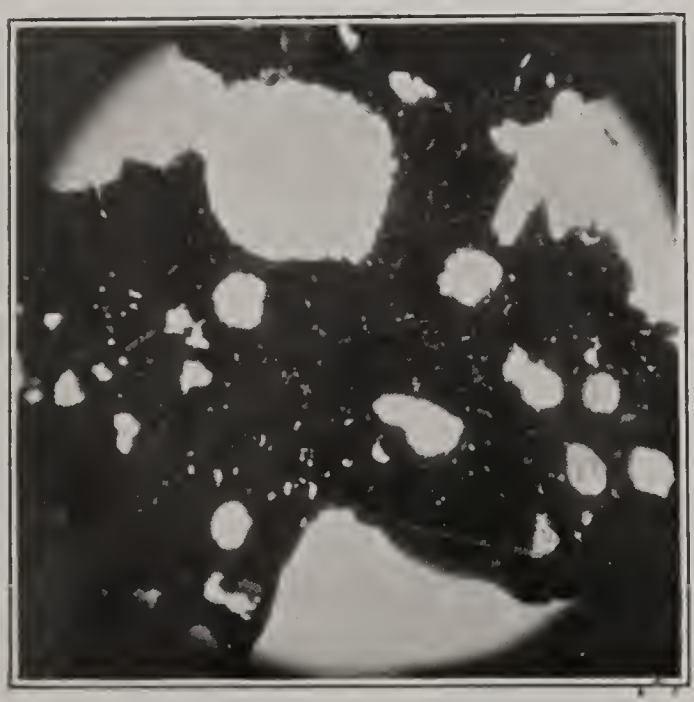
Cooled from Liquid State and Crystalline. Large Excess Light Colored Ferro-silicates. No Cellular Structure.



ROTARY KILN NODULES FROM FLUE DUST

Magnified 40 Diameters

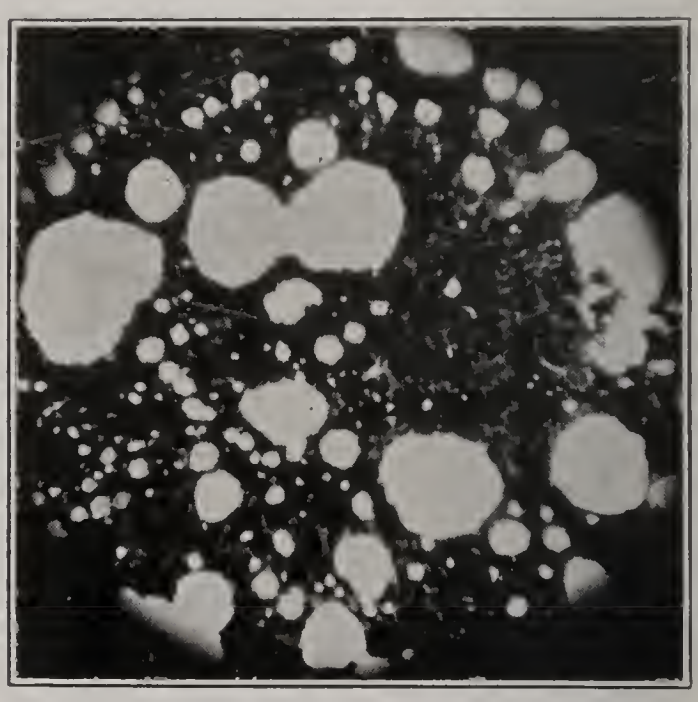
Cooled After Complete Fusion and Crystalline. Large Excess Light Colored Ferro-silicates. Note Similarity to Puddle Cinder. No Cellular Structure.



SINTER FROM FLUE DUST

Magnified 40 Diameters

Complete Absence of Light Colored Ferro-silicates. Whole Mass Dark Opaque Iron-oxide. No Crystals and Only Slightly Fused. Cellular Structure Fully Developed.



SINTER FROM GRANULAR HEMATITE ORE

Magnified 40 Diameters

Traces of Light Colored Ferro-silicates. Larger Part of Mass Dark Opaque Iron-oxide. Few Crystals and Only Slightly Fused. Cellular Spaces Predominate.

American Ore Reclamation Company

THE American Ore Reclamation Company is engaged in the licensing and engineering of plants for the sintering and desulphurizing of iron bearing material, and acts as consulting engineers with respect to the treatment of iron ore material that can be beneficiated by sintering.

The Company operates principally under the Dwight & Lloyd patents for continuous down-draft sintering, and is also licensed to use the intermittent process of sintering with separate tilting pans, the Heberlein up-draft process, and the rotary kiln, which represent a total of 52 patents covering the art of sintering.

Sintering is a comparatively recent art in the iron industry. It is the process of agglomerating fine ore material into a mass that is suitable for blast furnace use. Sintering may be illustrated as the making of flour into biscuits. With the use of the fine ores from the Mesaba Range in Minnesota and the resulting increase in make of flue dust at blast furnaces, many attempts were made to reclaim the valuable iron in the flue dust by briquetting. This means of treatment has not proven very satisfactory since to secure a firm bond the process is expensive, and when the bond is fickle the briquettes quickly return to dust.

The briquette is a porous mass and the spaces are filled with air, so that the mass must be heated to first expel the air to allow the reducing gases of the furnace to come in contact with the ore particles, which delays the reduction, and the mass is easily disintegrated into dust. Sinter, made by the continuous down-draft process, is cellular in structure, providing an open and large area of contact between ore and reducing gases; and as the cell walls are quickly heated to the temperature required for reduction, an economy in coke consumption results from the use of sinter.

To quote Schinz's law (in his "Action of the Blast Fur-

High Type of Sintering Plant With Overhead Storage Bins.
Steel Construction.

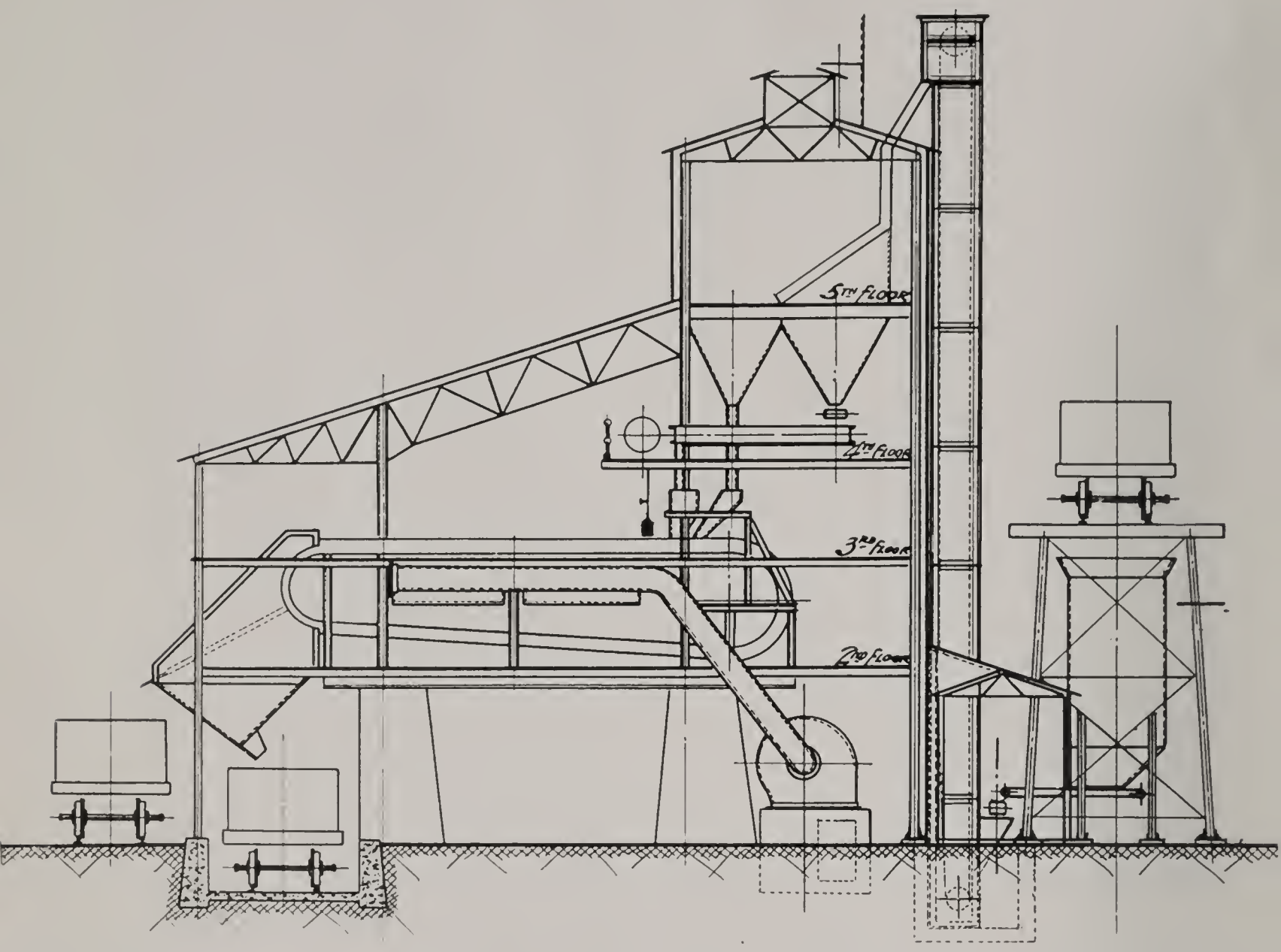
nace"): "A chemical action can only take place between two bodies, however great their affinity, if they are in intimate contact with each other; and the rapidity of this action will be so much greater, the more numerous the points of contact are." The material which provides the greatest area of contact is more readily and economically reduced in the furnace.

The iron bearing materials treated by sintering include blast furnace flue dust, roll scale, magnetic concentrates, magnetic sands, high sulphur ore, pyrites cinder, Mayari ore, Mesaba Range Paint Rock, ore washery fines, etc. Any finely divided ore or ores containing high sulphur or high moisture and combined water can be converted into ideal material for use in the blast furnace. Flue dust sludge from blast furnace gas washers may be sintered by adding the sludge to a dry sintering mixture, instead of moistening the charge with water.

Sintering was first applied in the iron industry to the reclamation of flue dust, but it has since widened out into other fields and demonstrated its adaptability for treating pyrites cinder, magnetic ore concentrates and other fine ores or hydrated ores.

Through the country there are vast fields of low grade magnetic ore which can now be cheaply concentrated and by subsequent sintering is converted into an ideal ore, rich in iron for use in the furnace. Magnetic ore in the massive state is penalized in price in the ore market, not because it is magnetic oxide but on account of its compact structure, while sinter made from magnetic concentrates is no longer massive but open and cellular in structure, and deserves a preference for furnace use as compared with natural ores.

Silicate of iron, which composes heating furnace cinder and is difficult to reduce in the blast furnace, does not occur in the sinter produced by the continuous down-draft method.



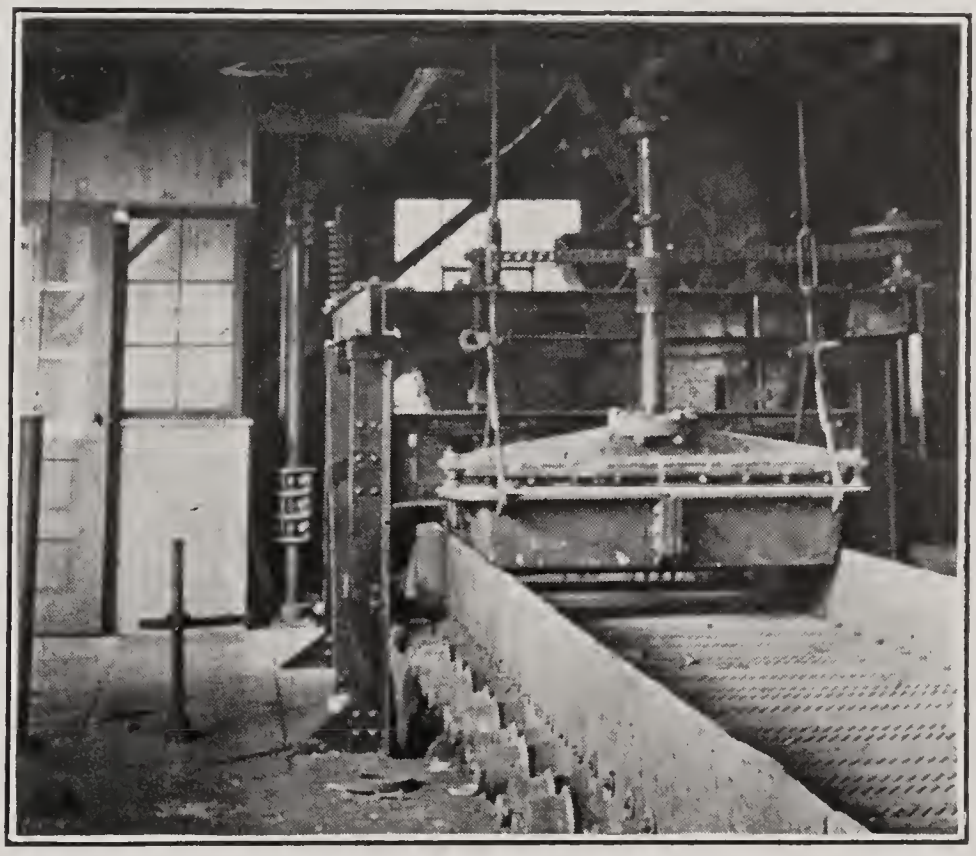
General Description of a Sintering Plant

A PLANT installation is made up of two main parts: the sintering machine proper and the raw materials plant, both forming a unit, of which the former is more or less standardized, but the latter made to conform to local conditions and materials. The following is a description of a typical plant.

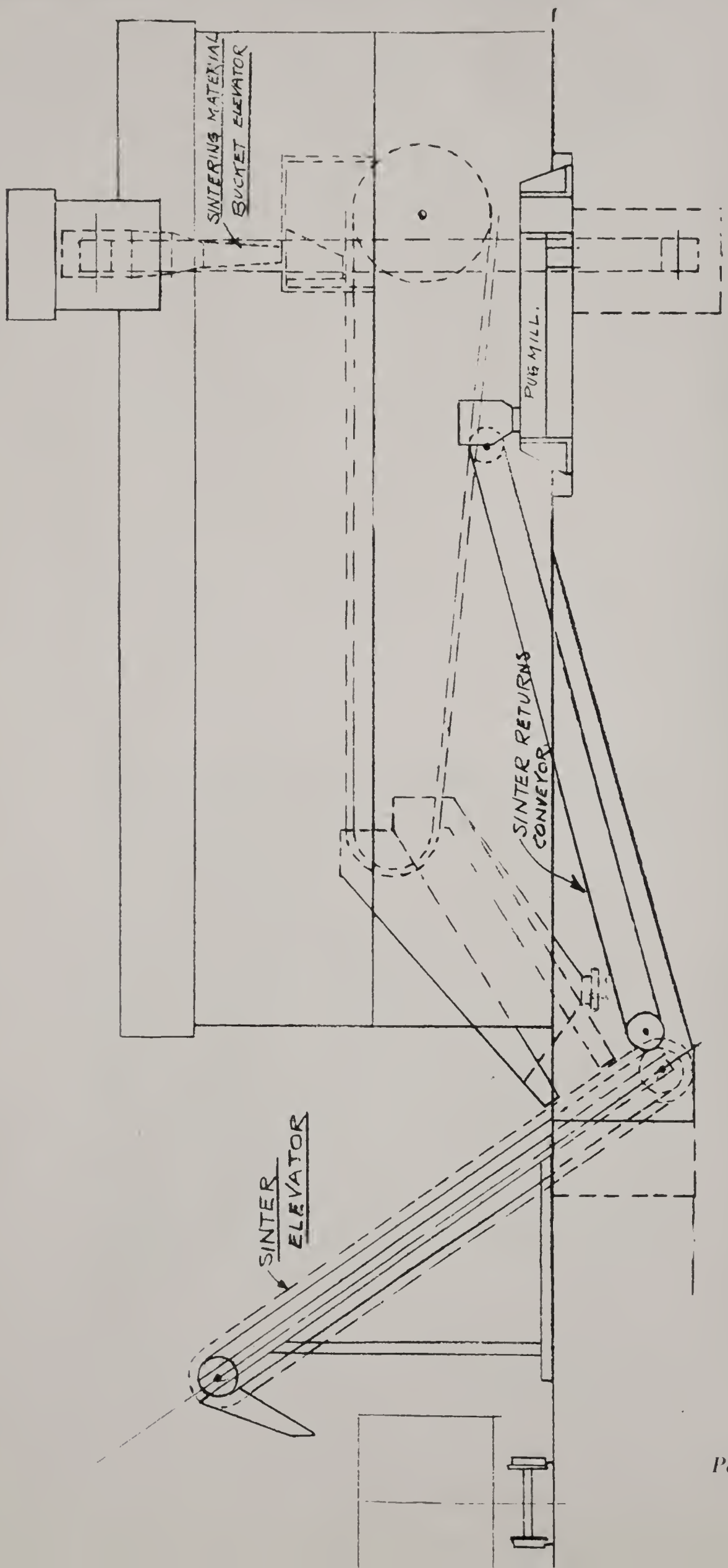
The materials to be sintered are delivered into a series of bins, the number and size of which depend on the kind and quantity of materials to be treated; or the raw materials may be dumped from the cars into a pit and transferred to the bins by a grab bucket.

In the case of flue dust, the screening of it is necessary, and a considerable quantity of coke is recovered for furnace use.

The bins are fitted with feeders of a special type which are driven as a group in synchronism with the sintering machine. The required composition of the sintering mixture is made up by adjusting the feeder gates and the total amount of sintering mixture delivered by the feeders is adjusted to suit the needs of the sintering machine at various speeds. The sintering mixture is carried to and thoroughly mixed and moistened in a pug mill or other mixing device and is delivered on to the grates of the sintering machine in a continuous layer of desired thickness and uniform permeability. This continuous layer is moved under an ignition burner where the fuel in the upper surface of layer is ignited and the charge then continues its movement over a wind box



A string of pallets showing the ignition burner used with blast furnace gas, and the grates. The moistening of the charge before feeding on to the grates gives the necessary cohesion to prevent the material from falling through.



Low Type of Sintering Plant.

connected to a suction fan which draws air down through all parts of the charge and the sintering action is progressive through the whole depth of the layer down to the grates. At the end of the sintering machine the sinter is discharged over a grizzly screen which thoroughly separates all fines from the sintered material and the fine sinter is returned to the sintering mixture to increase its permeability and thereby the rate of sintering is increased.

The whole operation of regulating the feeding of material and speed of sintering is controlled by a single lever.

Sintering Machines

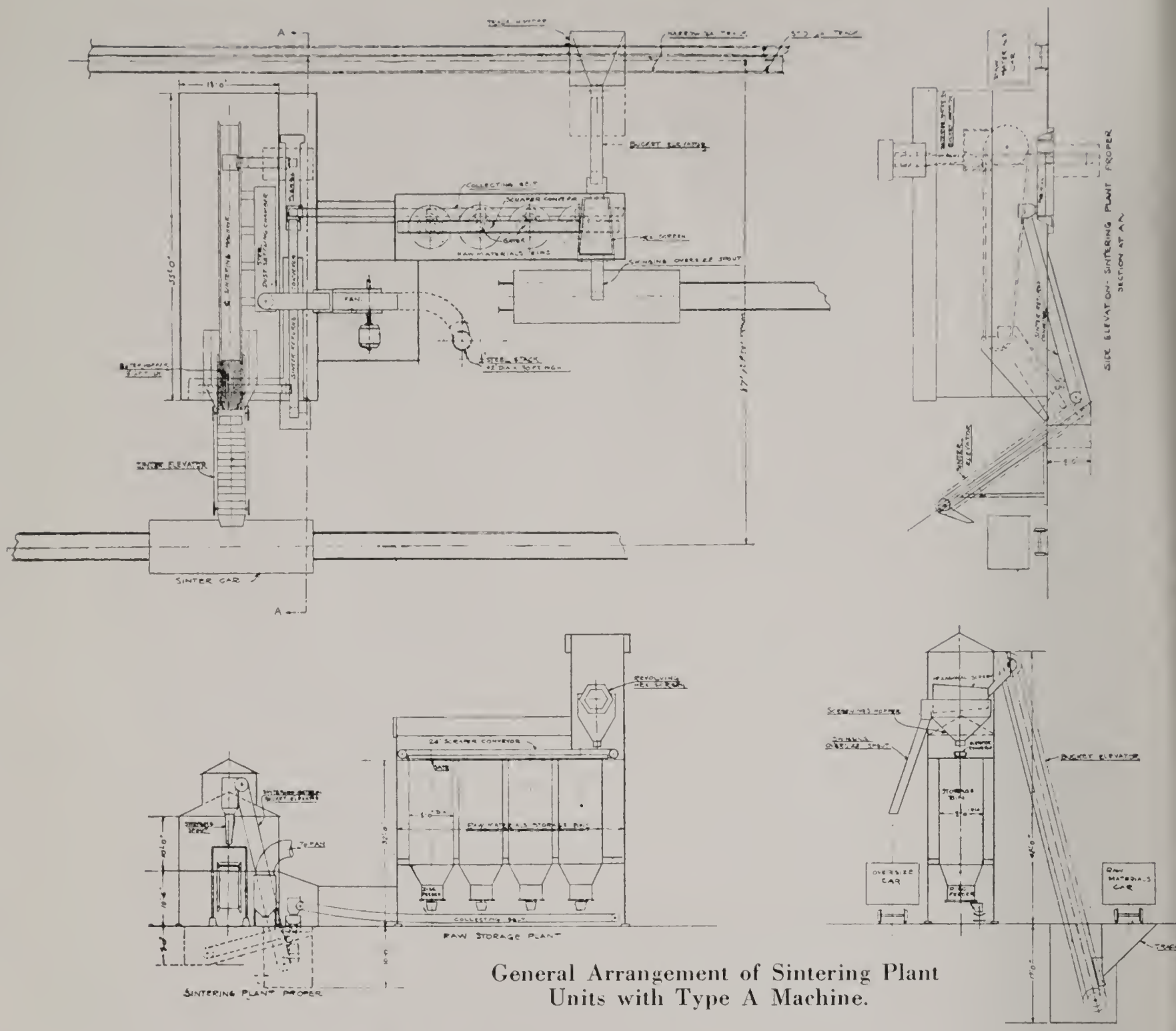
TYPE A.—Dwight and Lloyd sintering machine shown on plate I. has an active grate surface 42″ wide by 25′-6″ long with 90 sq. ft. of grate area. This machine is adapted to a one or a two blast furnace plant or where a small tonnage is required. The capacity of this machine, when sintering various materials, based on its performance in actual service, is as follows:

Flue Dust	125 to 150 tons sinter per day of 24 hrs.
Pyrites Cinder	150 to 175 tons sinter per day of 24 hrs.
Magnetic Concentrates	175 to 200 tons sinter per day of 24 hrs.

Type B.—Dwight and Lloyd sintering machine shown on Plate II. has an active grate surface 42″ wide by 57′-4″ long with 200 sq. ft. of grate area and has more than double the capacity of type A. The capacity of this machine, when sintering various materials, based on its performance in regular service, is as follows:

Flue Dust	260 to 310 tons sinter per day of 24 hrs.
Pyrites Cinder	300 to 375 tons sinter per day of 24 hrs.
Magnetic Concentrates	350 to 400 tons sinter per day of 24 hrs.

Type C.—Gayley Two-Strand sintering machine shown on plates III. and IV. is the largest capacity sintering ma-

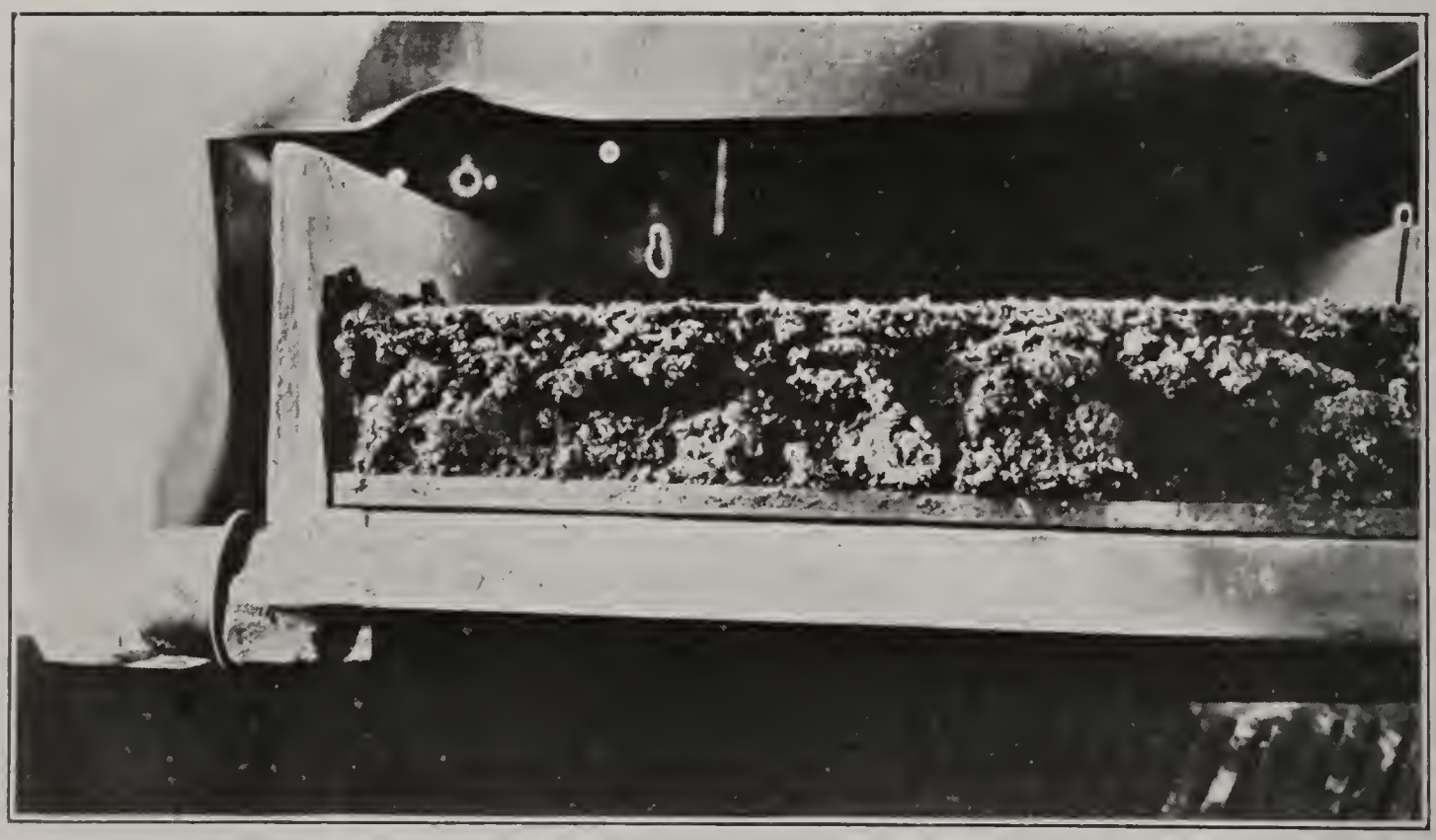


General Arrangement of Sintering Plant Units with Type A Machine.

Continuous Sintering Layer on Type B Machine.

chine so far developed. It has two parallel tracks of cars at the level of the operating floor. Both of these tracks are used for sintering and each has an individual equipment of feed hopper, ignition furnace, wind box, and suction fan. The parallel tracks are cross connected at each end with a combined car and transfer carriage which receives loaded cars from the discharge end of one track, dumps and screens the sinter, and delivers the empty cars to the feed end of the other track. The Two-Strand machine has few working parts, and the simplicity of construction coupled with large capacity particularly adapts this machine for sintering plants required to produce a large tonnage. The cars remain upright throughout the cycle of sintering operations except while the sinter is being discharged from the car in the transfer carriage, and for this reason they are particularly suited to the treatment of thick layers of material from one to four feet in depth which gives this machine a special value for dehydrating and sintering Mayari and similar ores.

Single Machine Plant. Wood Construction.



The Cake of Sinter Ready to Be Discharged From the Machine.

The Two-Strand sintering machine has an active grate surface 48″ wide by 56′-0″ long on each car track or a total of 450 sq. ft. of grate area. The capacity of this machine. is as follows:

Flue Dust	550 to 650 tons sinter per day of 24 hrs.
Pyrites Cinder	650 to 750 tons sinter per day of 24 hrs.
Magnetic Concentrates	750 to 900 tons sinter per day of 24 hrs.
Mayari Ore	1000 tons and upwards per day according to the depth of sintering layer.

Practice and Results

Flue Dust:

FLUE dust from different plants may contain from 8% to 20% of fuel. The lower percentage is sufficient for sintering, and any surplus fuel must be burned off and retards the sintering process. This surplus fuel should preferably be used to sinter fine ores containing no carbon, by mixing them with the flue dust in the sintering charge. An increased output can be obtained without appreciable increase in operating cost. As an illustration of this, a sintering plant which treated flue dust containing 16% to 18% fuel had production increased from 100 tons to 170 tons per day by the addition of magnetic ore concentrates.

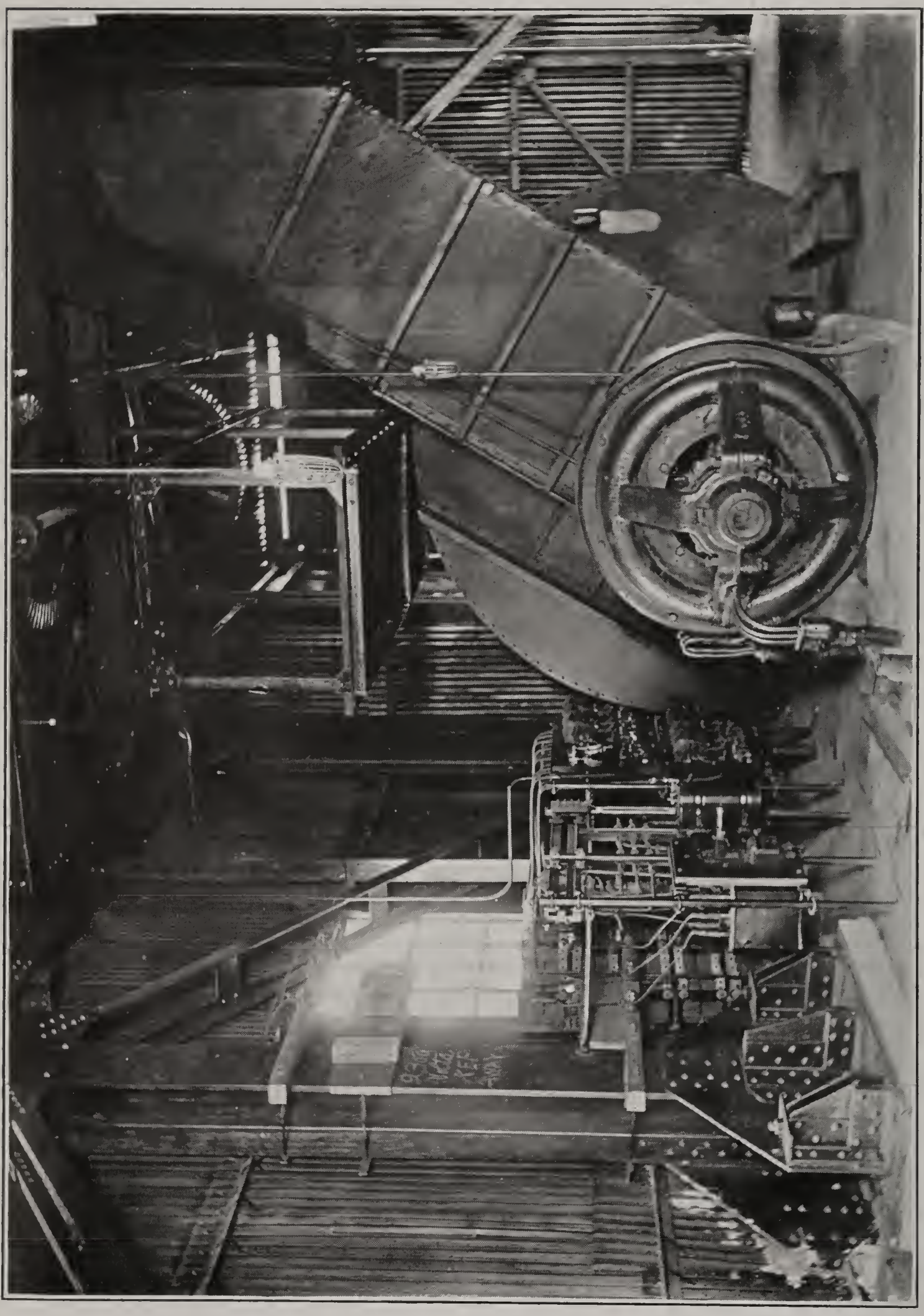
FLUE DUST—Dried at 212 Degrees

Analyses:	Flue Dust	Sinter	Flue Dust	Sinter	Flue Dust	Sinter	Flue Dust	Sinter
Iron	34.12%	40.67%	51.15%	57.70%	50.63%	56.53%	47.93%	55.02%
Carbon	15.00%	....	8.15%	....	9.69%	....	14.78%	....

Flue dust contains volatile matter in addition to carbon.

SIEVE TEST OF SINTERED FLUE DUST CONTAINING 18% CARBON

Over 2 in.	22.06%
2 in. to 1 in.	21.85%
1 in. to ¾ in.	19.93%
¾ in. to ¼ in.	34.06%
Below ¼ in.	2.10%
Total	100.00%



Double Inlet Fan. Diameter of Wheel 100 Inches. In Use With a Type B Machine.

COMPARISON OF PRODUCTS OF DOWN-DRAFT AND ROTARY KILN PROCESSES

	Down-Draft	Rotary Kiln
On ¾ in. Mesh	63.84%	26.8%
On 10 Mesh	35.12%	54.0%
On 60 Mesh	0.82%	18.2%
Below 60 Mesh	0.22%	1.0%
Total	100 00%	100.0%

The screen tests are presented for the purpose only of showing the general character of the sinter.

In practical operations the sinter shipped to the furnace from the continuous down-draft machine is passed over a ½ inch screen, and the fines are returned to the sintering mixture where they are of great advantage through increasing the permeability of the charge, and thereby the rate of sintering. The admixture of fines to the charge produces a firmer sinter.

Pyrites Cinder and High Sulphur Ore:

Pyrites cinder and other high sulphur ores are sintered and desulphurized in one operation. The cinder contains from 1.5% to 5% sulphur, which is reduced to 0.10% to 0.15% in the sintered product. About 8% to 10% of fuel is required.

Analyses:	Pyrites Cinder.	Sintered Product.
Iron	56.28%	61.00%
Sulphur	4.41%	0.07%

MIXTURE OF PYRITES CINDER AND FLUE DUST

Analyses:	Pyrites Cinder.	Flue Dust.	Average Mixture.	Sintered Product.
Iron	56.28%	33.00%	46.97%	57.10%
Sulphur	4.41%	0.18%	2.72%	0.12%
Carbon	0.00%	24.00%	9.60%	....

Type B Machine Set Up in Shop and Loaded With Pig Iron For Testing.

Magnetic Ore:

Magnetic ore concentrates are ideal for sintering. The surfaces of the concentrate grains quickly become pasty and adhesion through the mass is obtained more rapidly and at a lower temperature than with hematites, and the machine can be run faster. If the concentrates contain 1% to 3% sulphur the fuel used varies from 5% to 3% respectively.

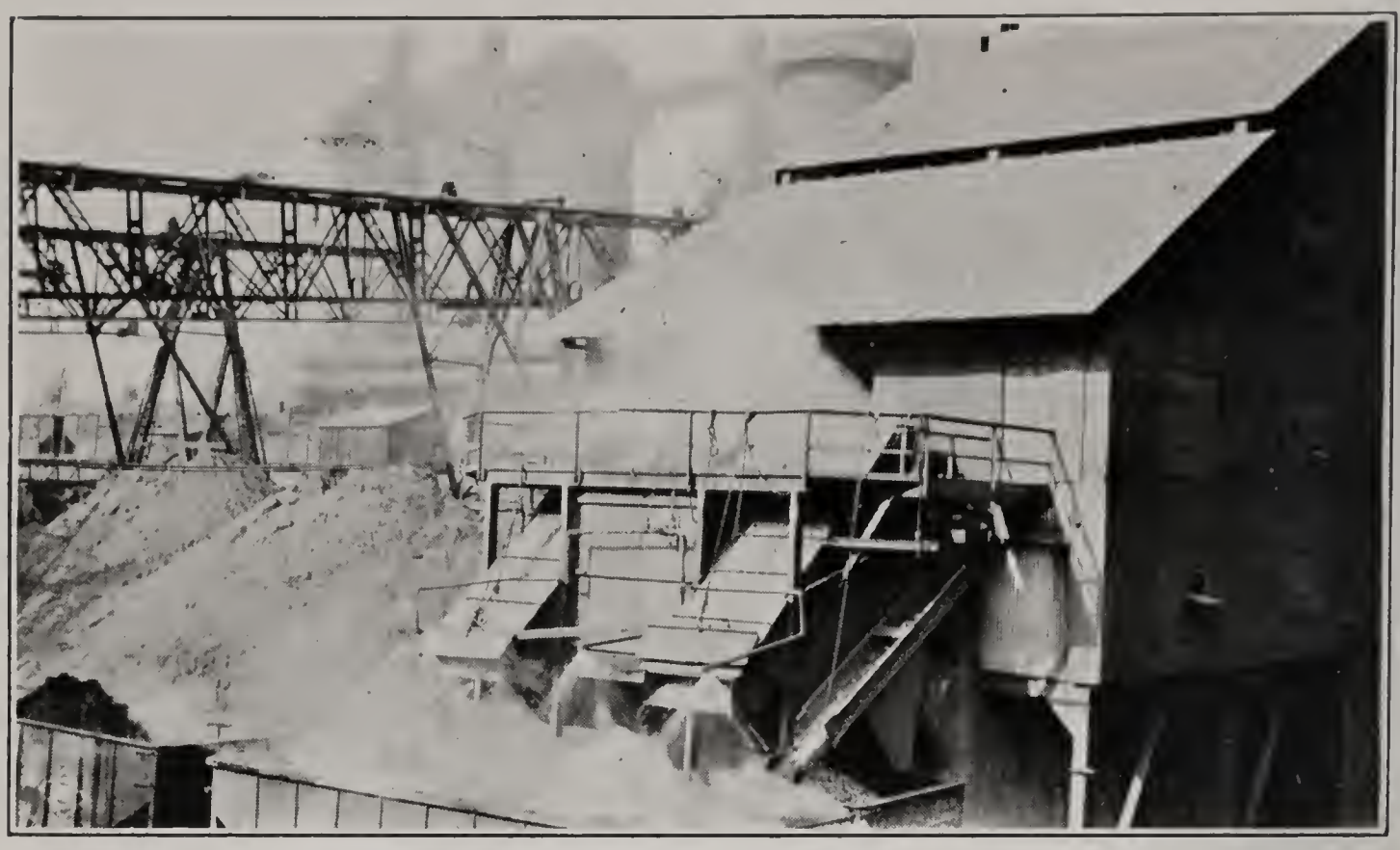
Mayari Ore:

Mayari ore is more cheaply sintered by the down-draft process and provides a material far more desirable for the blast furnace than is obtained from the rotary kiln. A screen test of sintered Mayari ore made by the continuous down-draft process shows as follows:

Over 2 in.	45.0%
2 to 1 in.	24.0%
1 to ¼ in.	18.0%
¼ to 1/10 in.	6.0%
Through 10 mesh on 20	5.0%
Through 20 mesh	2.0%
	100.0%

The sintering of this kind of ore, which is finely subdivided and carries high moisture, is greatly facilitated by passing it through a revolving drum to ball the material, and by mixing with it the sintered fines the ore is materially dried and made more permeable to the air draft. In this shape it can be treated in layers with a depth of 3 to 4 feet.

Type C, Two-Strand machine, which permits of any height of sides on the cars, is especially adapted to this purpose.



Discharge End of a Two Machine Sintering Plant.

A Car Load of Sinter.

Mayari ore requires about 10% of fuel for sintering.

Analyses:	Mayari Ore.		Sintered Product.		
	Natural.	Dried.	A.	B.	C.
Iron	39.50%	48.43%	54.26%	52.79%	53.97%
Combined water		13.50%	....	....	....
Moisture	18.50%	....	....	....	....

Carbonate Ore:

Spathic iron or carbonate ore is readily beneficiated by sintering. Results obtained by the use of 5% fuel are shown as follows:

Analyses:	Carbonate Ore.	Sintered Product.
Iron	32.87%	49.70%
Carbon Dioxide	27.30%	0.06%
Sulphur	1.97%	0.09%

Mesaba Range Paint Rock:

The so-called paint rock of the Mesaba Ore Range in Minnesota which carries high moisture and combined water, is converted into a valuable iron ore when sintered. The following result was obtained with 8% fuel.

Analyses:	Paint Rock.		
	Natural.	Dried.	Sintered Product.
Iron	40.01%	47.23%	52.70%
Combined water	....	8.98%	....
Moisture	15.28%	....	....

FUELS USED

COKE braise and the excess carbon in flue dust are the commonly used sintering fuels for treating carbon free sintering materials like pyrites cinder, finely divided ores and concentrates, etc. Equally good results have been obtained from the use of charcoal braise, bituminous screenings, and anthracite dust.

All of the fluid fuels ordinarily available are used for igniting the sintering charge. The continuous sintering layer moving under the ignition furnace at a uniform speed makes possible the use of cheap blast furnace gas for ignition fuel at blast furnace plants. Where blast furnace gas is not available the sintering layer is ignited with natural gas, coke oven gas, illuminating gas, or fuel oil as may be economically provided.

ADVANTAGES

The American Ore Reclamation Company has demonstrated the following points of advantage to be obtained by the continuous method in its process and product:

PROCESS:

The continuous process is more economical than the intermittent.

The process converts flue dust and concentrates into a superior grade of ore.

The continuous process uses the cheapest fuel for ignition.

The sinter is made with the least admixture of fuel.

The sulphur in the sinter can be reduced to any percentage desired.

High sulphur ores are desulphurized when being sintered, while roasting only removes sulphur.

The sinter is made with less consumption of power than required by any other method.

The production is the greatest per square foot of sintering grate area.

The installation cost per square foot of grate area is lower per ton of product than any other process.

The sintering charge is dumped from sintering machines in small units and is easily screened; consequently, no fine material is sent to the furnace.

PRODUCT:

The sinter contains no silicate of iron.

The sinter is cellular, not porous.

Cellular sinter is quickly reduced in the furnace.

The sinter is not glazed on the surface.

The sinter is a first class merchantable ore.

Sinter causes faster driving and more uniform working. and keeps the furnace walls clean.

Sintered material does not produce flue dust in the furnace.

The sinter does not disintegrate on exposure to the weather.

Sinter increases production and decreases coke consumption in the furnace.

Sintered magnetic ore concentrates are the equal of natural hematites.

Sintering removes the objection to the use of roll scale.

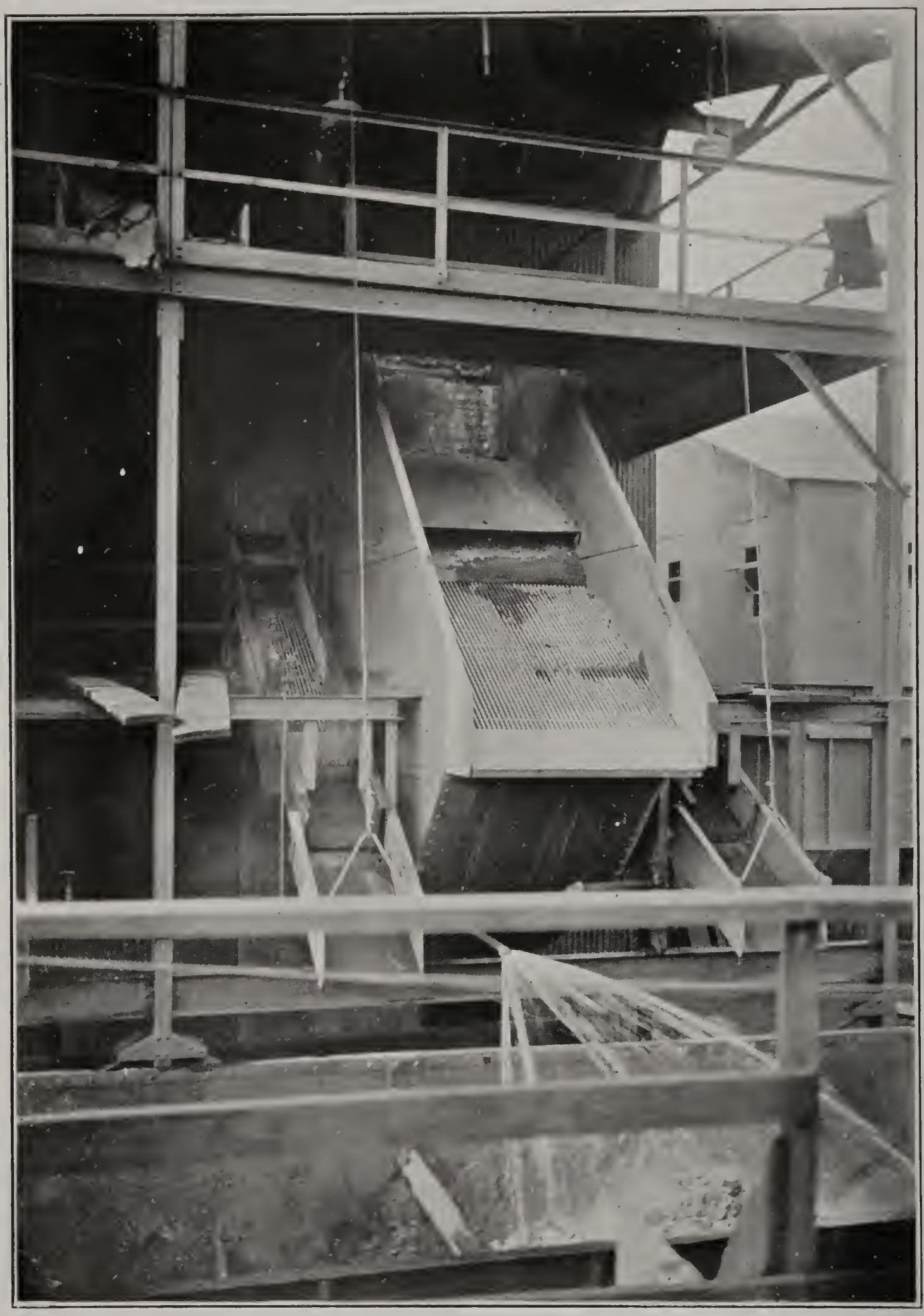
Flue dust sinter is enriched by the admixture of fine ores, pyrites cinder and roll scale.

The sinter is of uniform size which produces regularity in furnace working.

SOME USERS

The following companies are using the continuous downdraft sintering process for iron bearing materials:

United States Steel Corporation
Jones and Laughlin Steel Company
Colorado Fuel and Iron Company
Alan Wood Iron and Steel Company



The Discharge End of Sintering Machine Showing Screen to Remove the Fines.

E. and G. Brooke Iron Company
Eastern Steel Company
Toledo Furnace Company
Pyrites Company, Limited
American Sintering Company
Virginia Iron, Coal and Coke Company
Oriskany Furnace, Lavino Furnace Company
Virginia Industrial Chemical Company
Woodstock Operating Corporation, Alabama
Low Moor Iron Company of Virginia
Marting Iron and Steel Company
Davison Chemical Company

CONSULTATION

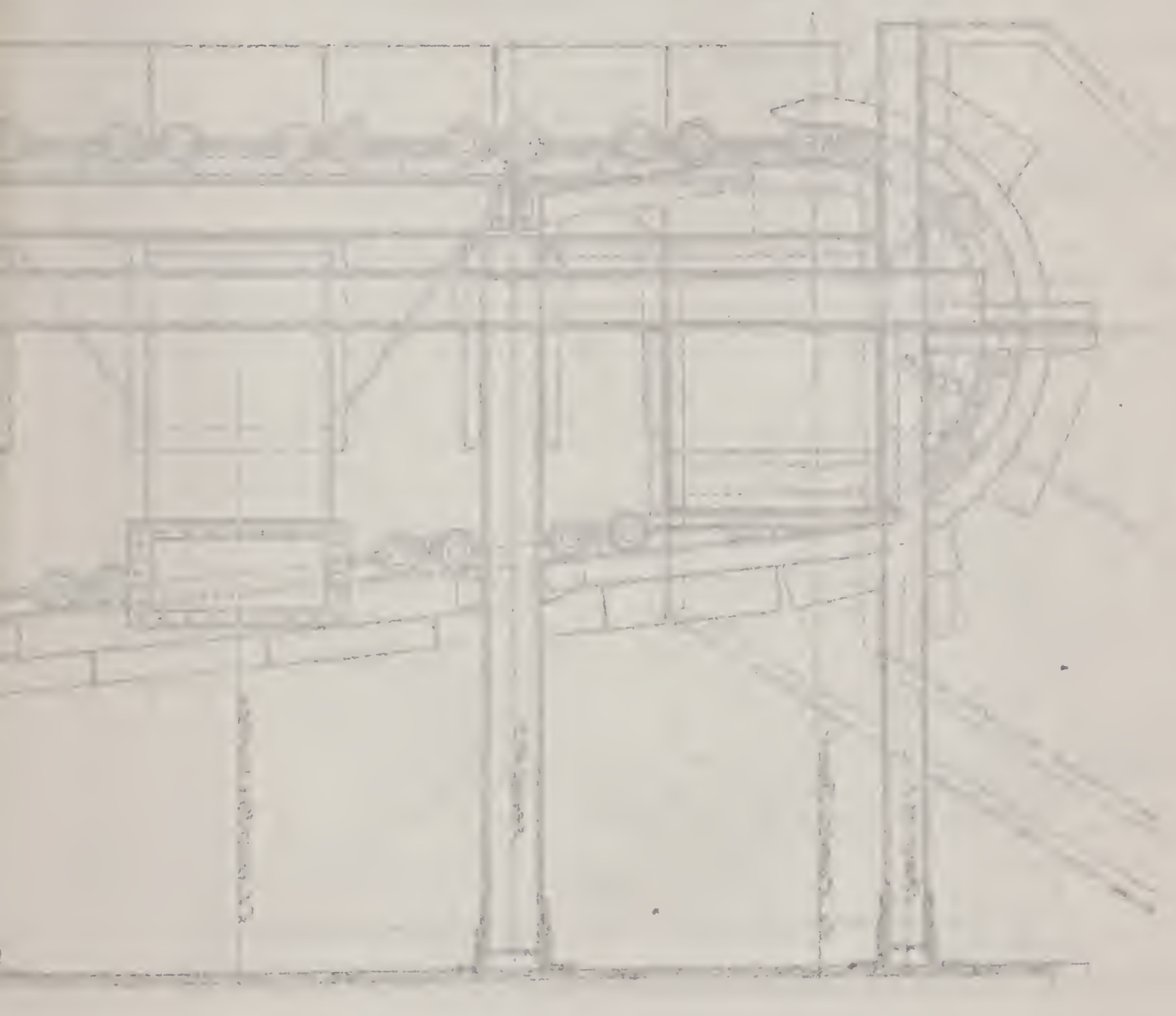
The American Ore Reclamation Company invites you to consult their Engineering Department on sintering problems who will make a study and submit a preliminary plan free of charge.

A Single Machine Plant in Use For Sintering and Desulphurizing Pyrites Cinder. Wood Construction.

IN THE CONTINUOUS PROCESS THE WHOLE OPERATION IS CONSTANTLY IN VIEW

Plate I

Plate I



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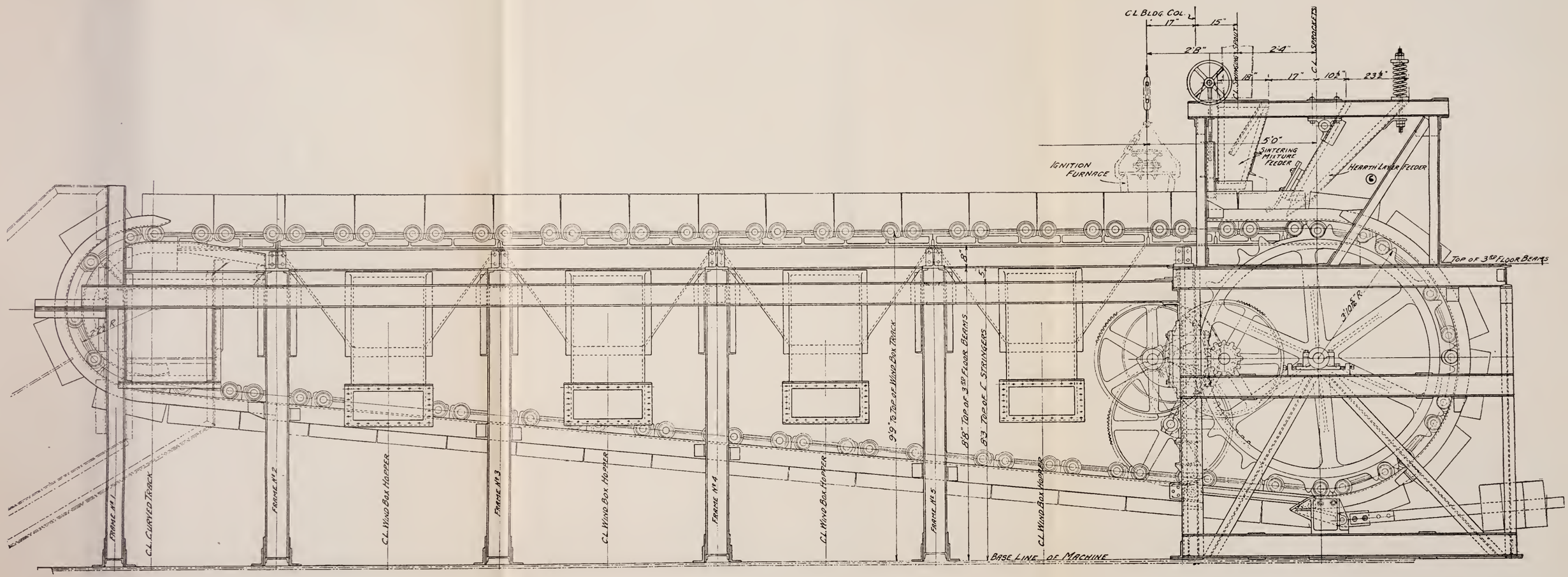


Type A. Dwight and Lloyd sintering machine.

Plate II

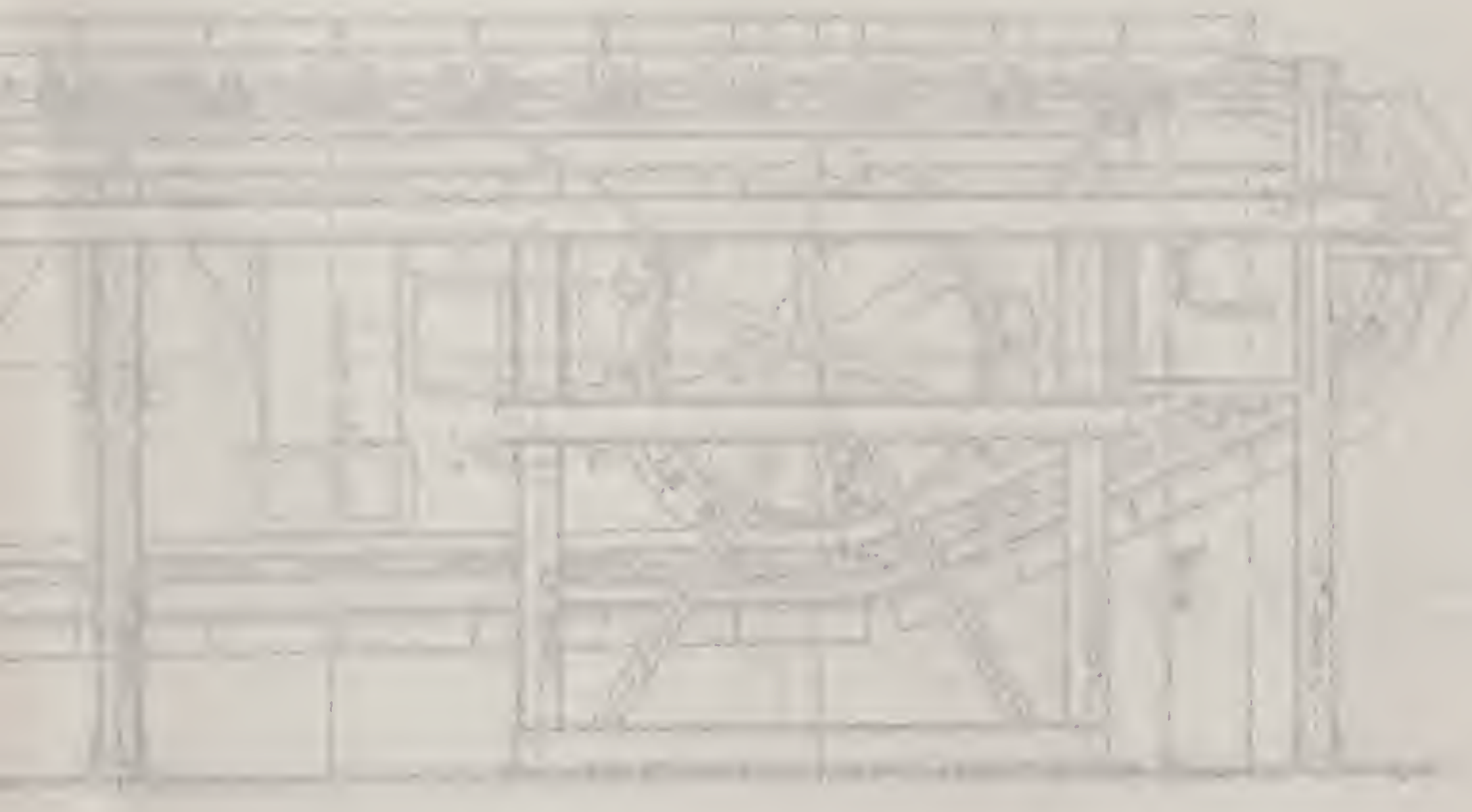
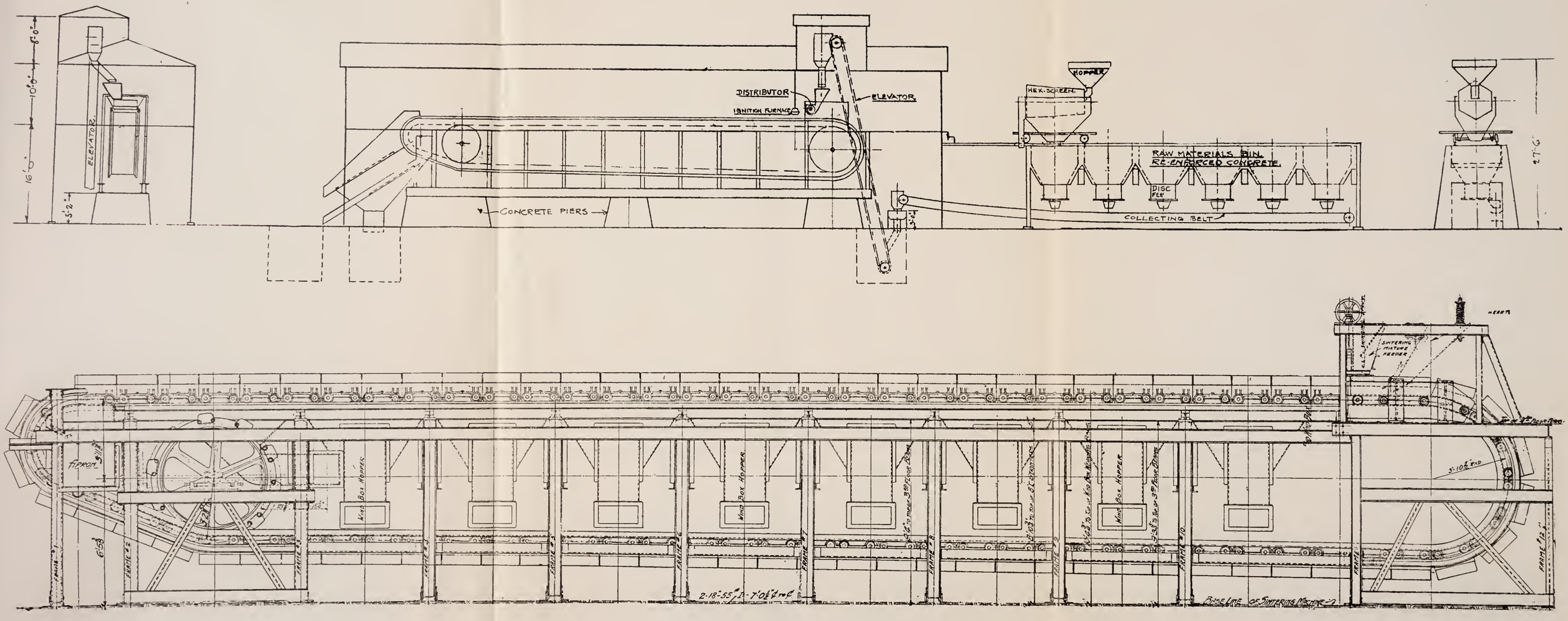


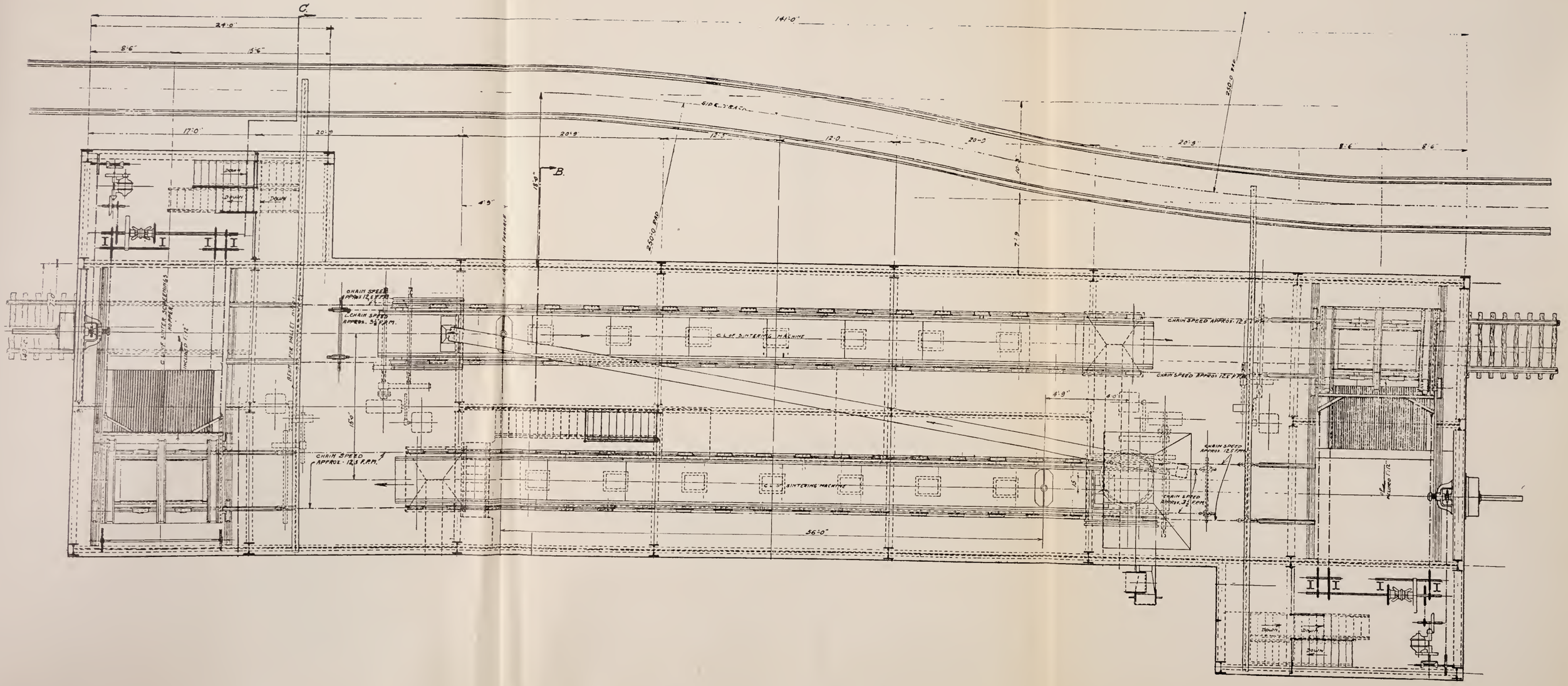
Plate II



Type B. Dwight and Lloyd sintering machine, with a general arrangement of the plant.

Plate III

Plate III



Plan—Gayley Two-Strand machine plant.

Plate IV

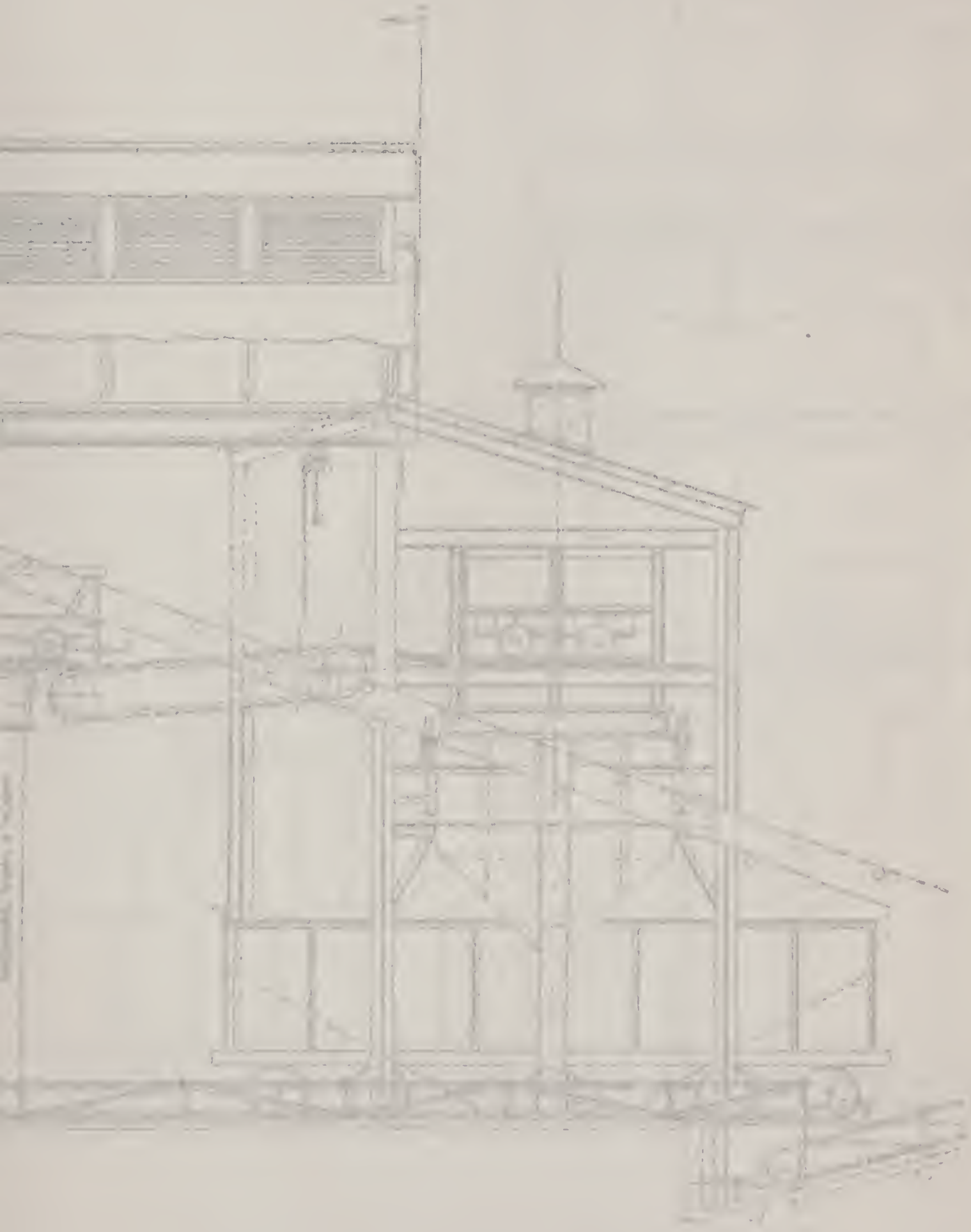
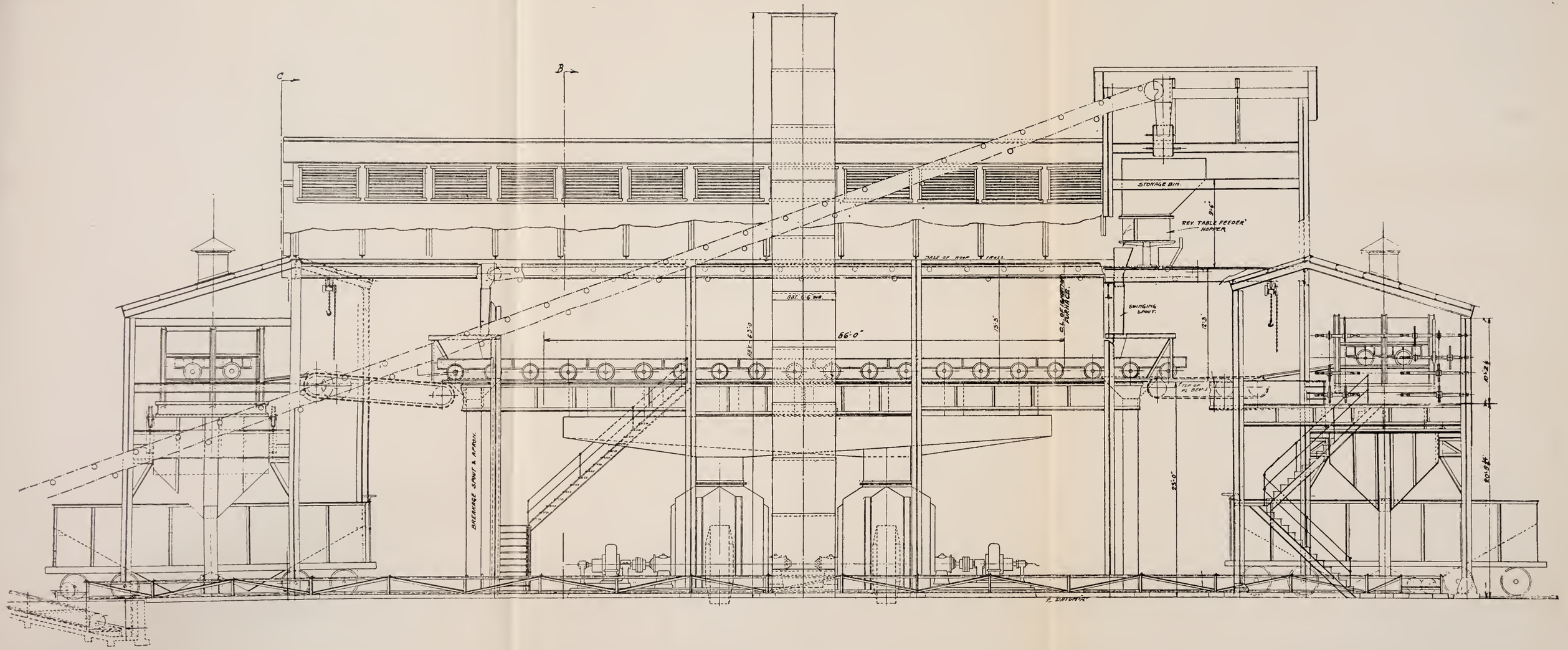


Plate IV



Elevation—Gayley Two-Strand machine plant.